UNIVERSITI TEKNOLOGI MARA

DIELECTRIC PROPERTIES OF HUMAN SKIN IN VIVO IN THE FREQUENCY RANGE 20-38GHz

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ABSTRACT

The increasing use of microwave and millimeter-wave radiation in communications and radar, necessitates more understanding of dielectric properties of various human tissues for evaluation of potential hazards to humans. In this research, the dielectric properties of human skin in vivo were measured in the frequency range of 20 - 38 GHz. Complex reflection coefficients were measured by pressing the palm region of human skin in vivo against a waveguide sensor which consists of coaxial cables, coaxial-to-rectangular waveguide transition and Teflon^{TM} impedance transformer. Complex permittivities (ε^*) are calculated from complex reflection coefficients (S_{11}) by implementing a formulation of an open-ended rectangular waveguide radiating in to the half-space of lossy dielectric material. Results are reported for 42 healthy volunteers which are in the age group of 19 to 40 years. This research also provides experimental design according to the protocol guidelines given by Universiti Teknologi Mara (UiTM) ethics committee. A research protocol was under consideration of Medical Research and Ethics Committee of the Ministry of Health, Malaysia from June 2003 to May 2004. Since June 2004, a modified version of the protocol was under consideration by the UiTM Medical Research Ethics Committee and only been approved on April 2005. This is the first reported result of human skin in vivo in the frequency range of 20 – 38 GHz with statistically significant number of volunteers (42 people from Malay cohort) in the age group of 19 – 40 years. As per protocol, complex reflection coefficient data were measured. Then, complex permittivities, attenuation coefficients and emmisivities were calculated in the 20 – 38 GHz frequency range. Statistical analysis was performed on the complex permittivity, skin depth and emmisivity data. Then, mean values, standard deviations values and 95% confidence interval values are reported at 15 chosen frequencies in the 20 - 38 GHz range.

Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my work, unless otherwise indicated or acknowledged as referenced work. This topic has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

In the event that my thesis be found to violate the conditions mentioned above, I voluntarily waive the right of conferment of my degree and agree be subjected to the disciplinary rules and regulations of Universiti Teknologi MARA.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

There are two sources of electromagnetic wave; natural sources and human-made sources. Electromagnetic fields are present everywhere in our environment but are invisible to human eyes. Radiofrequency (RF) fields are part of the electromagnetic spectrum. RF is defined as those within the frequency range 30 MHz-300 GHz [1].

RF fields from natural sources have very low power densities. The prime natural source, the sun, its RF intensity is 0.01 mW/m^2 in the frequency range of 3-300 GHz. The majority of RF fields found in the immediate environment are from human-made sources, can be found in three places; community, home and workplace [2].

Microwaves are a specific category of radio waves that fall into radio frequency radiation. Radar, satellite links and microwave communications use 3 - 40 GHz, are human-made sources. So, safety effects always being the issue concerning the expanding use of microwave and millimeter wave technology, raising the question whether this technology can cause risk to human health.

To protect our health, there are some standards being set for many food additives, concentration of chemicals in water or air pollutants. Similarly, field standard is set to limit the over exposure to electromagnetic field levels present in our environment. A country has to set their own guidelines and standards for exposure to electromagnetic fields for the safety of their people.